Panhandle Watershed Case Study

TMDL BASINS 05

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Executive Summary

Flooding is the most common and costly disaster in the United States. Over 98% of counties in the entire United States having experienced a flood and just one inch of water causing up to $25,000 in damage (FEMA 2018). Flooding can impact a community's social, cultural, environmental and economic resources; therefore, producing sound, science-based, long-term decisions to improve resiliency are critical to future prosperity and growth. To meet the longer-term goals to protect life and property, in 1990, FEMA created the National Flood Insurance Program's (NFIP) Community Rating System (CRS) program, a voluntary program for recognizing and encouraging community floodplain management activities. Nearly 3.6 million policyholders in 1,444 communities participate in the CRS program, but this is only 5% of the over 22,000 communities participating in the NFIP.

The Florida Department of Emergency Management (FDEM) contracted with FAU to develop data to enable local communities to reduce flood insurance costs through mitigation and resiliency efforts by developing watershed management plans. There are several steps to address the development of watershed plans including the development of a watershed planning template and development of support documents to establish risk associated with community risk within the watershed.

The effort discussed herein focuses on the development procedures for a screening tool to assess risk in the Panhandle TMDL 05 area of Florida. The watershed located in Northwest Florida combines readily available data on topography, ground and surface water elevations, tidal data for coastal communities, open space and rainfall to permit an assessment of the risk of inundation of property within the TMDL 05 Basin. Such knowledge permits the development of tools to permit local agencies to develop means to address high risk properties.

1.0 Introduction

In 1972, the Florida Legislature created the Northwest Florida Water Management District (NWFWMD) within the passage of the Water Resources Act (Pratt et al., 1996). The NWFWMD encompasses an area of about 11,200 square miles. The Panhandle Basin borders the Suwannee River Water Management District. The Panhandle consists of 5 TMDLs, and this report will focus on the eastern basin, TMDL 05; it is home to the City of Tallahassee, the Capital of Florida. The basin is coastal, so flood risks from rainfall, wet season thunderstorms and tropical storm activity are concerns for local officials and the nearly 350,000 people who live in the watershed. Figure 1 depicts the Ochlockonee, TMDL 05, shown in green, within the Panhandle region.

The Panhandle is the least populated and most lightly visited portion of Florida and is closer in appearance to its Deep South neighbors than the tropical backdrop that characterizes the rest of the state.

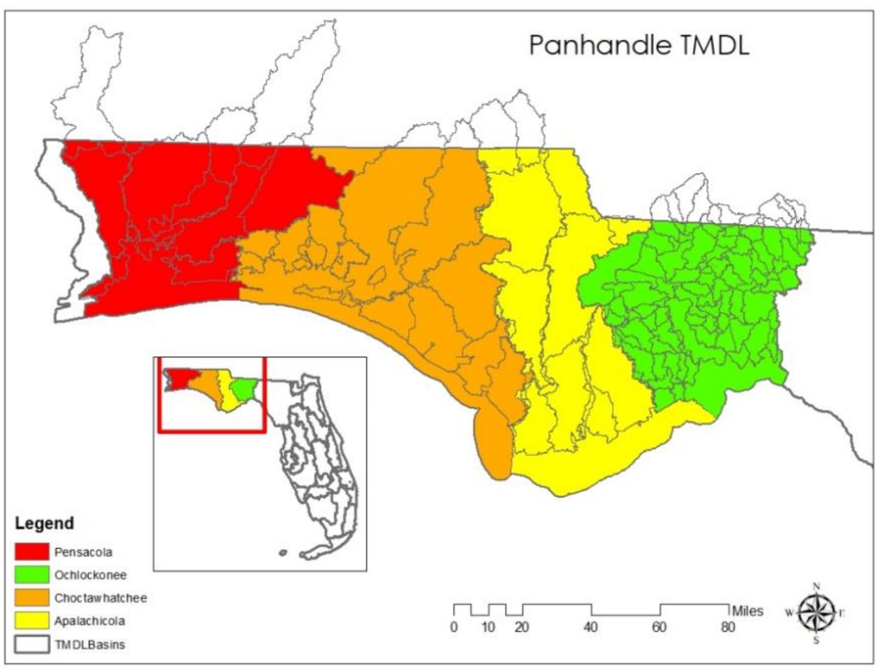

Figure 31. Location of Panhandle

2.0 Summary of Watershed

2.1. General Description of Watershed

2.1.1. Climate/Ecology

Nature reigns supreme in North Florida; forests, preserves and parks remain home to wildlife such as black bears, bald eagles and the rare Florida panther (smilingglobe.com, 2020). Cool freshwater springs can be seen throughout the panhandle area allowing for some recreational opportunities such as tubing, cave diving, etc. Normal annual rainfall ranges from about 55 to 67 inches per year; the average annual rainfall is generally highest in the western portion of the NWFWMD and lowest in the eastern portion (Pratt et al., 1996). There are two distinct rainy seasons each year, the first resulting from frontal storm systems during the winter and early spring, and the second occurring during the summer as a result of afternoon and evening thunderstorms.

2.1.2. Topography and Soils

The regions rolling, hilly terrain more closely resembles areas within Alabama or Georgia than peninsula Florida. Elevations in the highlands area range from 50 to 345 feet above sea level. The highest point in Florida, at 345 feet, is located near the town of Lakewood, which is almost on the Alabama border (smilingglobe.com, 2020). The major physiographic features include the Northern Highlands, and the Coastal Lowlands (Pratt et al., 1996). Panhandle beaches are famous for their white ‘sugar sand’, composed of quartz washed down from the Appalachian Mountains by ancient rivers. Elevations are low, ranging from sea level to about 100 feet above sea level. The native soil and topography create an environment that is highly permeable and can absorb a significant amount of water into the soil: however, the change in the land use has resulted in the flow of water leading to impermeable land where the water collects in pools or runs off rapidly where development has taken place, in direct contrast to the natural condition. The land in many areas is poorly drained due to a flat topography and associated high water table.

2.1.3. Boundaries/Surface Waters

Drained by several large rivers, the region has extensive pine and hardwood forests, springs and swamps. Barrier islands, beaches, and tidal marshes border most of the Gulf Coast (smilingglobe.com, 2020). The key elements of the watershed include the bays (Apalachee Bay), a few lakes, the rivers (Ochlockonee River), the canal system and the rainfall over the area. Figure 2 depicts the TMDL 05 Basin subdivided into 2 HUCs that will later be analyzed individually through the use of CASCADE.

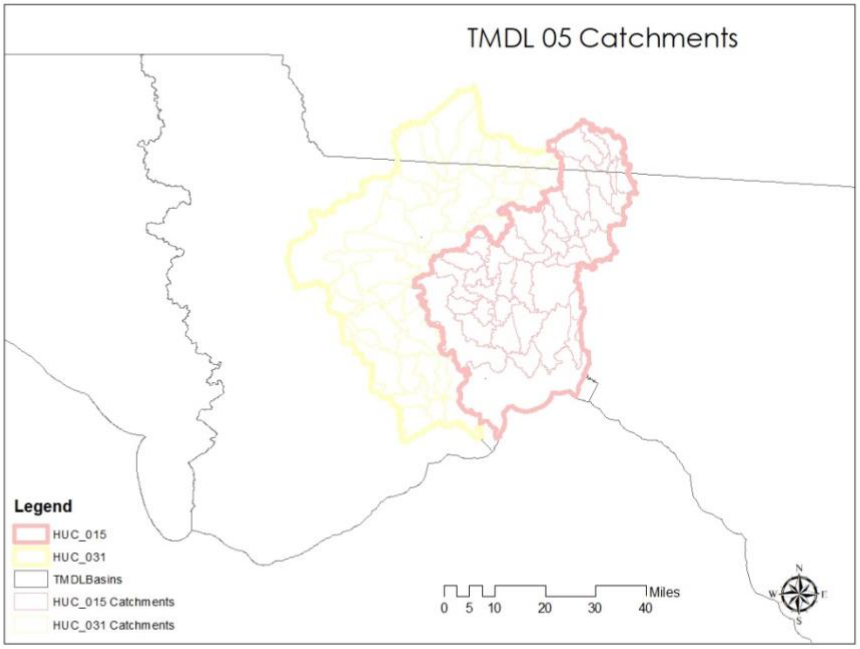

Figure 32. TMDL 05 Catchments

2.1.4. Hydrogeological Considerations

In northwest Florida, the hydrogeologic framework is divided into four groups of sediments that constitute distinct hydrogeologic systems, and each system is a compilation of lithologic beds that have similar hydrogeologic characteristics. (Pratt et al., 1996). Systems are defined by their ability to accelerate or hinder the flow of water and, thus, are not constrained by lithologic or stratigraphic boundaries. In descending order from land surface, the four systems are: Surficial Aquifer System, which includes the Sand-and-Gravel Aquifer; Intermediate System; Floridan Aquifer System; and Sub-Floridan System. In northwest Florida, the Ad Hoc Committee recognized three aquifer systems, which includes the surficial aquifer system, the intermediate aquifer system and the Floridan aquifer system, and two confining units, which includes the intermediate confining unit and the sub-Floridan confining unit. The subsurface characteristics of each system vary both laterally and with depth. The nature of the variability determines ground water availability or the degree of detention for the respective system at any given location.

2.2. Socio-economic Conditions of the Watershed

2.2.1. Demographics (US Census, 2010)

As of the 2010, the 3 counties that make up the TMDL 05 Basin had a total population of 341,567 people and 129,757 households. The average household size for the TMDL 05 was 2 people per household. The population consists of roughly 18.63% under the age of 18, 18.13% who were 65 years of age or older. The racial makeup of the county was 69.20% White, 26.47% Black or African American, 1.67% Asian, 0.50% Native American, 0.10% Pacific Islander. As of the 2010, the median income for a household in the county was $54,051, and roughly 16.83% of the population were below the poverty line.

2.2.2. Property

According the US Census, the median property valuation, as of 2018, is roughly near $150,000.

2.2.3. Economic Activity/Industry

As of 2018, the total number of employments within the TMDL 05 area is 35,379, with roughly 2,700 establishments. The total retail sales are roughly $4 million (US Census, 2018). Cool freshwater springs bubble up everywhere, affording recreational opportunities such as tubing, swimming, snorkeling, cave diving and sightseeing on glass-bottom boats (smilingglobe.com, 2020). Outdoor enthusiasts can canoe wild and scenic rivers, camp on an open prairie, cycle along the Gulf of Mexico, catch their own scallops, kayak past centuries-old forts and more.

3.0 Watershed Analysis

3.1. Data Sets

3.1.1. Topography

Figure 3 depicts the results of the LiDAR DEM, using 3-meter tiles, processed conducted for the Panhandle Basin. The highest points are approximately 350 feet above sea level near border of Georgia, and the lowest points are 3 feet below sea level shown along the coast of the panhandle.

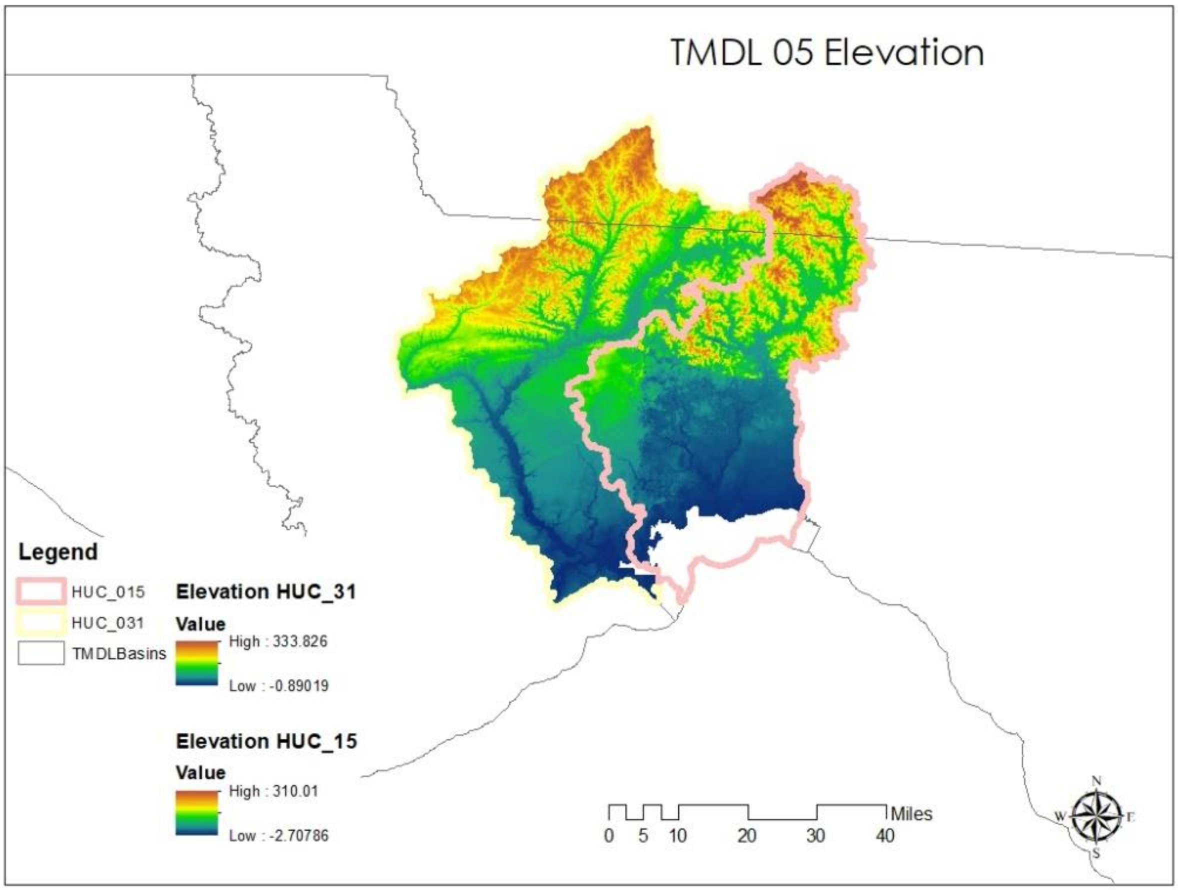

Figure 33. Topography of TMDL 05 based on Lidar DEM

The area with the highest elevation belongs to Attapulgus Creek (HUC_031) at 333 feet, which are located within the State of Georgia, seen in Table 1. Upper Ochlockonee (HUC_031) has the largest area at roughly 960 million square feet. The catchments were separated by the bodies of water within them, as well as by the location of water stations.

Table 4. TMDL 05 Elevation

HUC_015

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM	ACRES
1	Wards Creek	1	292736807	368625340.752454	67.687912	308.662567	240.974655	164.776034	48.910271	48236009938.289955	8462.473387
2	Lake Drain	2	381067163	479854290.446113	32.399254	296.437317	264.038063	138.390884	43.288346	52736221510.960129	11015.938715
3	Lost Creek	3	402519847	506868327.49392	-1.188061	153.751587	154.939648	55.505856	34.043103	22342208585.191986	11636.095672
4	Munson Slough	4	239922605	302119685.353886	5.594488	249.676224	244.081736	71.625875	45.43329	17184666524.140266	6935.713622
5	Pinhook River	5	156774808	197416811.410396	-1.209551	45.438267	46.647817	14.065342	8.055835	2205091236.425734	4532.066378
6	St. Marks River	6	725154896	913142673.706591	-1.428075	249.554337	250.982412	60.050513	56.116036	43545923341.150322	20962.871297

HUC_031

NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM	ACRES
Attapulgus Creek	1	53666294	580482267.469815	87.256065	333.638153	246.382088	239.316643	48.5225	12843237314.284889	13326.039198
Upper Ochlockonee River	2	88685093	959263627.844536	59.306797	301.341766	242.034969	158.452103	52.257144	14052339449.991856	22021.662715
Little River	3	23906217	258581951.844587	64.170303	311.001129	246.830826	180.527615	59.280777	4315732343.237427	5936.22479
Mid Ochlockonee River	4	36363953	393331238.628212	15.575866	239.200714	223.624848	111.799444	44.160644	4065469733.046241	9029.64276
Telogia Creek	5	59451974	643063161.26611	16.086918	313.949829	297.862911	168.105675	71.196833	9994214241.642069	14762.698835
Sopchoppy River	6	38487974	416305743.374776	0	123.343758	123.343758	52.701344	26.06928	2028367968.66227	9557.064816
Lower Ochlockonee River	7	51676505	558959685.148284	-0.745836	97.711472	98.457307	35.885503	24.570627	1854437382.432408	12831.948695

3.1.2. Groundwater

Figure 4 depicts the ground water levels within the TMDL 05 region. The highest point reaches 90 feet near the Georgia border, and the lowest point is at 0 feet along the coastline.

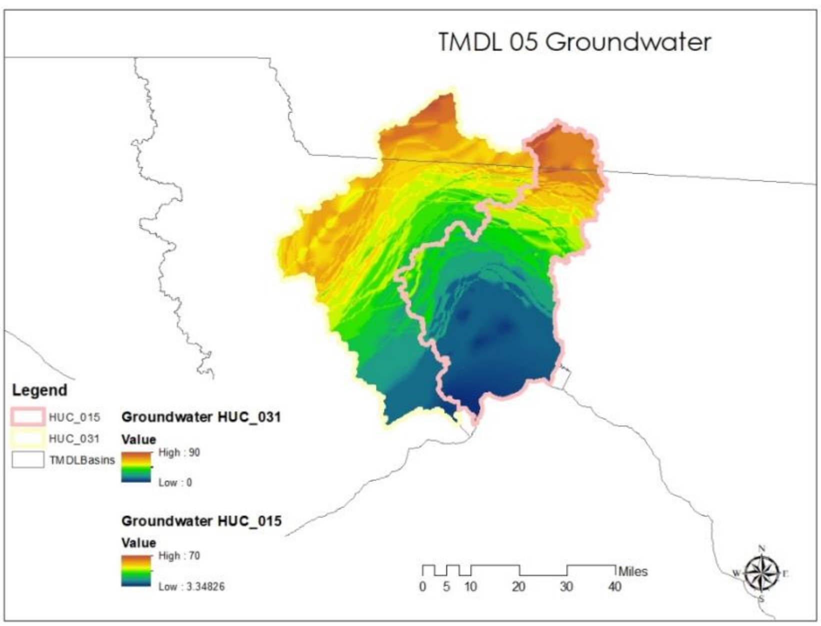

Figure 34. TMDL 05 Groundwater

3.1.3. Impervious Areas

Figure 5 represents the impervious areas, primarily roads in the TMDL 05 region. These are areas where water cannot seep into the soil and as a result seep to unsaturated areas. Most of the impervious areas are located near the Tallahassee.

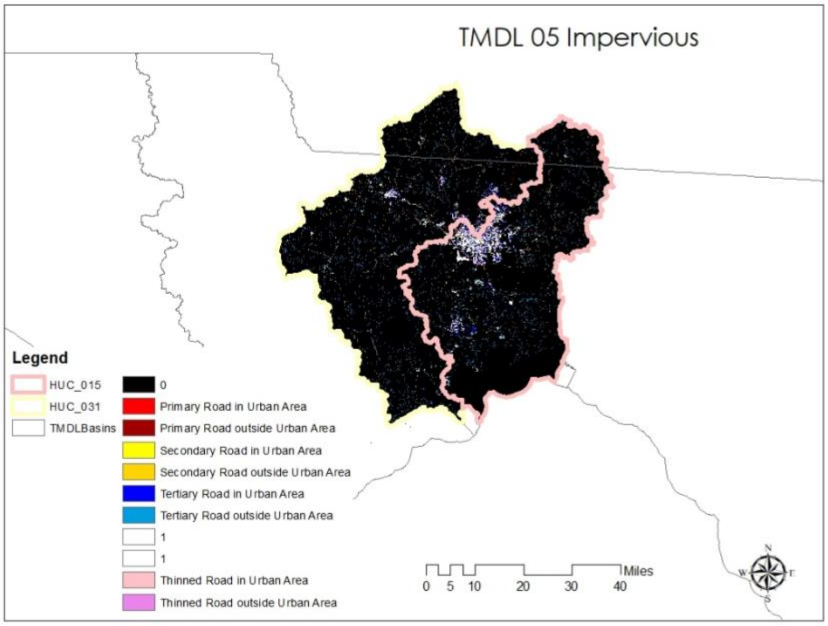

Figure 35. TMDL 05 Impervious Areas

Figure 6 is the water holding capacity. The highest capacity is at 0.68 feet and the lowest is nearly at zero feet.

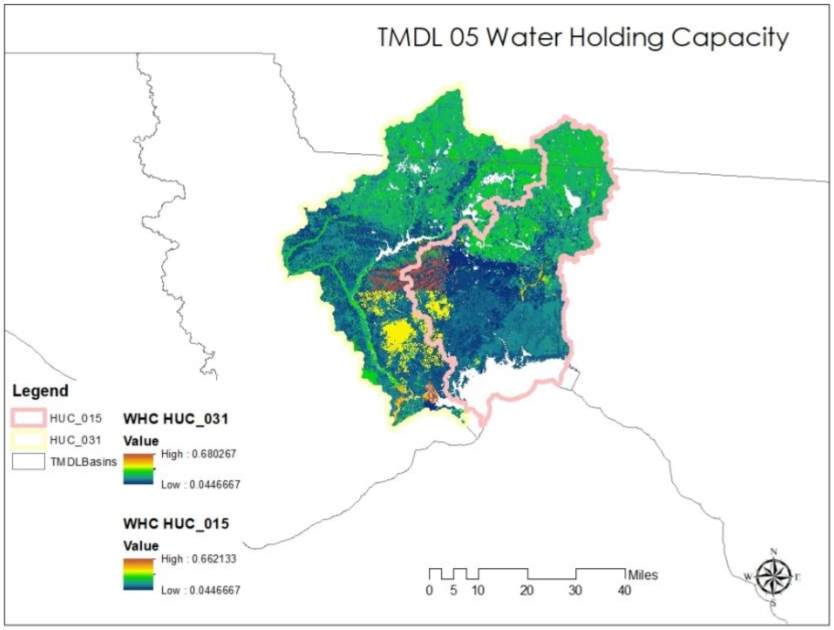

Figure 36. TMDL 05 Water Holding Capacity

3.1.4. Ground Storage

Figure 7 represents the ground storage within the TMDL 05 region. The highest levels of ground storage are located near the areas of Tallahassee. The lowest levels are concentrated in the middle of HUC_015.

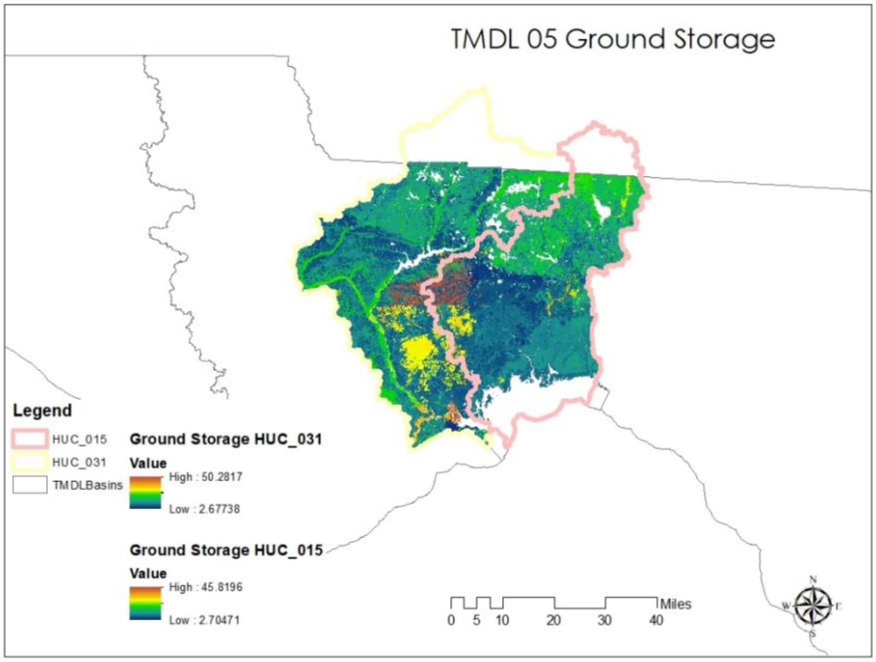

Figure 37. TMDL 05 Ground Storage

The area with the highest ground storage level occurs within the Attapulgus Creek (HUC_031) at 257 feet, seen in Table 2.

Table 5. TMDL 05 Ground Storage

HUC_015

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Wards Creek	1	408203	367382700	15.357651	236.499237	221.141586	104.470249	46.003886	42645069.075375
2	Lake Drain	2	533047	479742300	0.143459	228.29184	228.14838	92.149112	42.3689	49119807.78237
3	Lost Creek	3	563172	506854800	0	122.030075	122.030075	36.355739	26.030447	20474534.438605
4	Munson Slough	4	335682	302113800	0	218.941193	218.941193	50.804211	41.691477	17054059.000576
5	Pinhook River	5	219332	197398800	0	29.623034	29.623034	4.612898	5.302588	1011756.037103
6	St. Marks River	6	1014445	913000500	0	211.854126	211.854126	40.010475	47.311829	40588425.900337

HUC_031

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Attapulgus Creek	1	644489	580040100	39.017921	257.097168	218.079247	169.550976	43.688621	109273738.708904
2	Upper Ochlockonee River	2	1064895	958405500	13.239975	236.847839	223.607864	107.036597	47.948005	113982736.670185
3	Little River	3	287357	258621300	14.847153	245.597534	230.750381	127.968078	55.089181	36772523.007393
4	Mid Ochlockonee River	4	437030	393327000	0	174.404221	174.404221	61.647189	39.755462	26941671.114006
5	Telogia Creek	5	714310	642879000	0	252.782227	252.782227	106.105992	68.373278	75792571.412415
6	Sopchoppy River	6	462541	416286900	0	92.683655	92.683655	30.734659	17.682028	14216040.108254
7	Lower Ochlockonee River	7	620996	558896400	0	57.16288	57.16288	14.195215	13.714274	8815171.905275

3.1.5. Precipitation

Figure 8, shown below, depicts the precipitation values within the TMDL 05 region. Precipitation flows from the north experiencing less rainfall with roughly 9 inches of rainfall, and the south portion experiencing higher levels of rainfall with approximately 13 inches of rainfall.

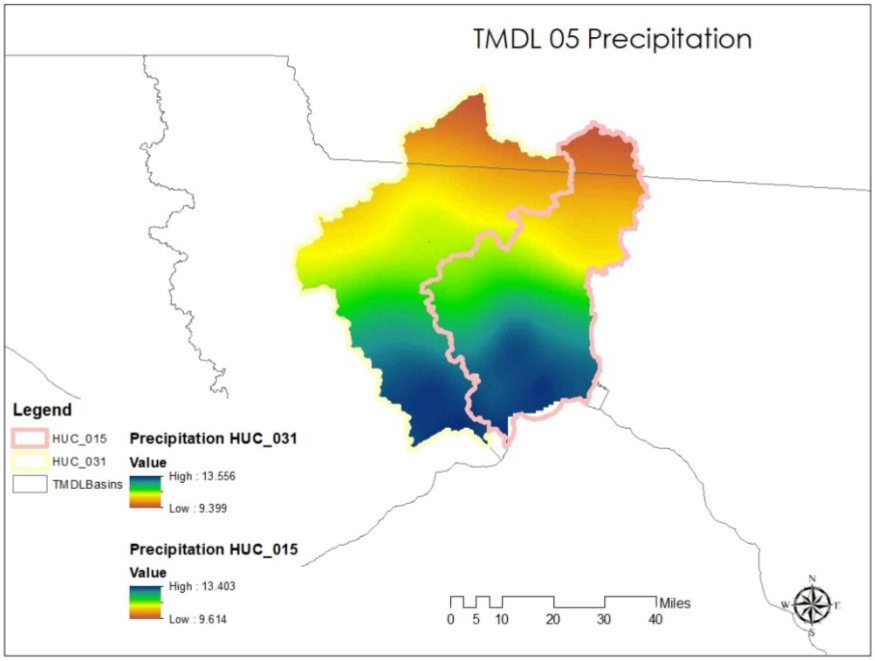

Figure 38. TMDL 05 Precipitation

Lost Creek, Pinhook River, St. Marks River (HUC_015) and Sopchoppy River, Lower Ochlockonee River (HUC_031) experiences the largest amount of rainfall with roughly 13.5 inches of rainfall, seen in Table 3. All these rivers are located in the south portion of the TMDL. The area with the lowest rainfall, nearly 9.5 inches, is located near Attapulgus Creek.

Table 6. TMDL 05 Precipitation

HUC_015

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Wards Creek	1	490	367053330.083239	9.637	10.678	1.041	10.04209	0.26686	4920.624005
2	Lake Drain	2	627	469678444.820798	9.992	11.15	1.158	10.665949	0.248024	6687.549997
3	Lost Creek	3	669	501140158.827933	11.387	13.223	1.835999	12.318102	0.563165	8240.809994
4	Munson Slough	4	395	295889929.352816	11.277	12.459	1.181999	11.691615	0.281608	4618.188003
5	Pinhook River	5	254	190268460.900292	12.164	13.212	1.048	12.800941	0.246763	3251.438999
6	St. Marks River	6	1210	906396998.776979	10.697	13.305	2.608001	11.981803	0.795908	14497.982017

HUC_031

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Attapulgus Creek	1	781	582856449.016909	9.449	10.966	1.516999	10.199403	0.38648	7965.734002
2	Upper Ochlockonee River	2	1278	953765098.391305	9.777	11.376	1.599	10.69881	0.446874	13673.07902
3	Little River	3	344	256725503.792339	10.711	11.31	0.599	11.085913	0.135962	3813.553999
4	Mid Ochlockonee River	4	508	379117895.135198	10.971	12.21	1.239	11.489685	0.292874	5836.760002
5	Telogia Creek	5	842	628380448.235899	10.577	12.341	1.764	11.161451	0.37824	9397.941996
6	Sopchoppy River	6	538	401506747.210111	11.774	13.466	1.691999	12.855998	0.460999	6916.527002
7	Lower Ochlockonee River	7	729	544049105.420392	12.167	13.549	1.382	13.107027	0.373018	9555.023003

3.1.6. Surface Waters

Figure 9 shows the location of existing water stations. The data provided from each water station will justify the results obtained from CASCADE. Some HUCs did not contain any existing water stations, however due to the flow of the rivers, the data collected from the basin upstream will be used to prove the validity of the results.

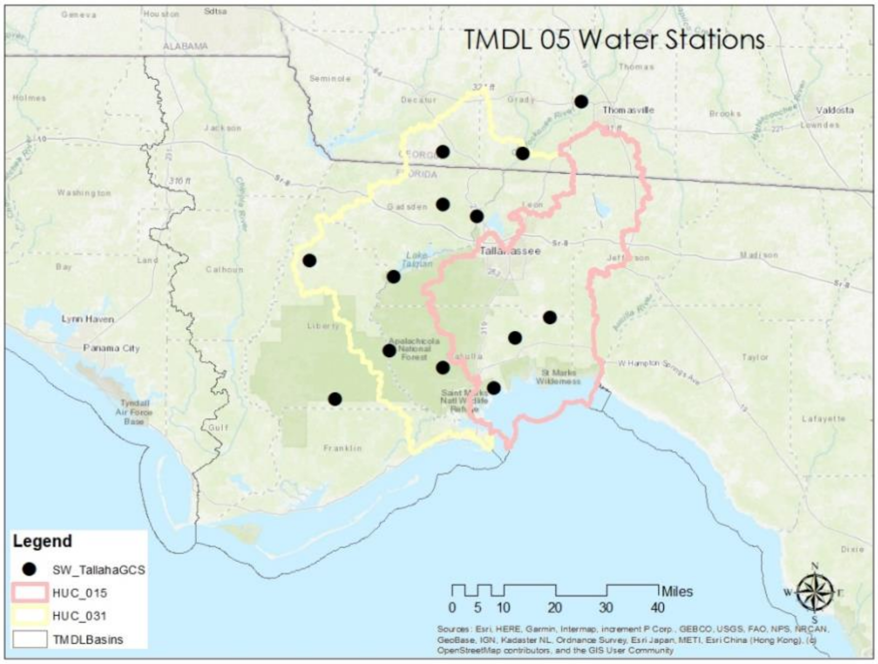

Figure 39. TMDL 05 Water Stations

3.1.7. Open Space

While the soil may have the capacity to store water, the type of land cover will either allow or prevent soil infiltration. If an area is covered by impervious surfaces, the rainfall will not infiltrate the soil causing surface runoff and increased flooding. Only those areas classified as open space, or pervious land, will minimize surface runoff, promoting soil infiltration and storage in the unsaturated zone. Therefore, incorporating impervious surfaces into the calculation of soil storage capacity is important. The National Land Cover Database was used to classify land as either pervious or impervious. Then, impervious surfaces were assigned a value of zero to designate all impervious areas as having no soil storage capacity since rainfall will simply runoff along the surface without any soil infiltration, preventing storage in the unsaturated zone. Figure 10 depicts the open spaces using a binary system. The open spaces are scattered across the TMDL The areas concentrated with open spaces are located north of the Tallahassee area. These areas are mostly located clustered within this one area.

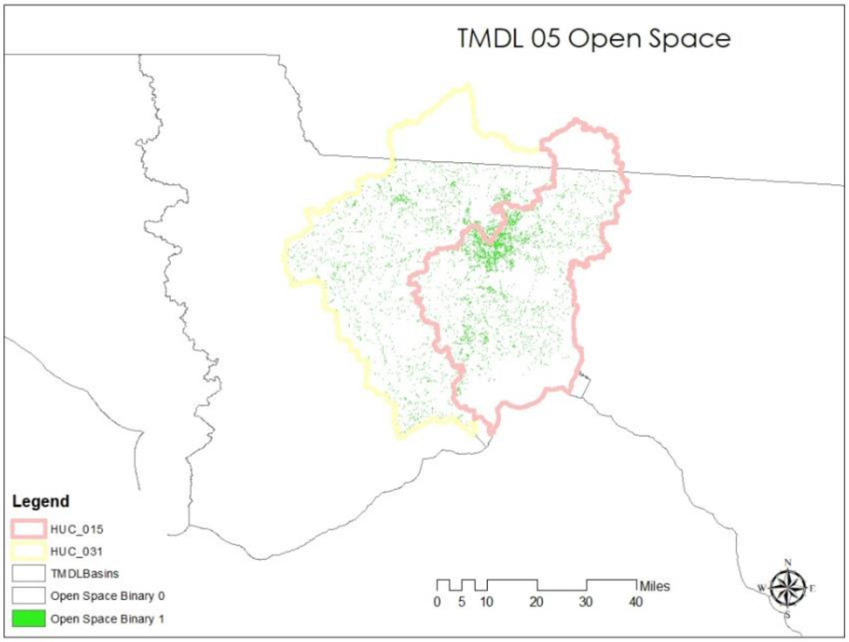

Figure 40. TMDL 05 Open Space

3.2. Modeling Protocol

CASCADE 2001 is a multi-basin hydrologic/hydraulic routing model developed by the South Florida Water Management District (SFWMD). The model develops solutions by basin. A basin is defined as an area where all the water that falls via rainfall stays in an area and travels to an outlet. The areas of the basin and the longest time it takes the runoff to travel to the most distance point to reach the point of discharge must be estimated. Rainfall is also needed. The waterway flow paths from ArcHydro as in Figure 11.

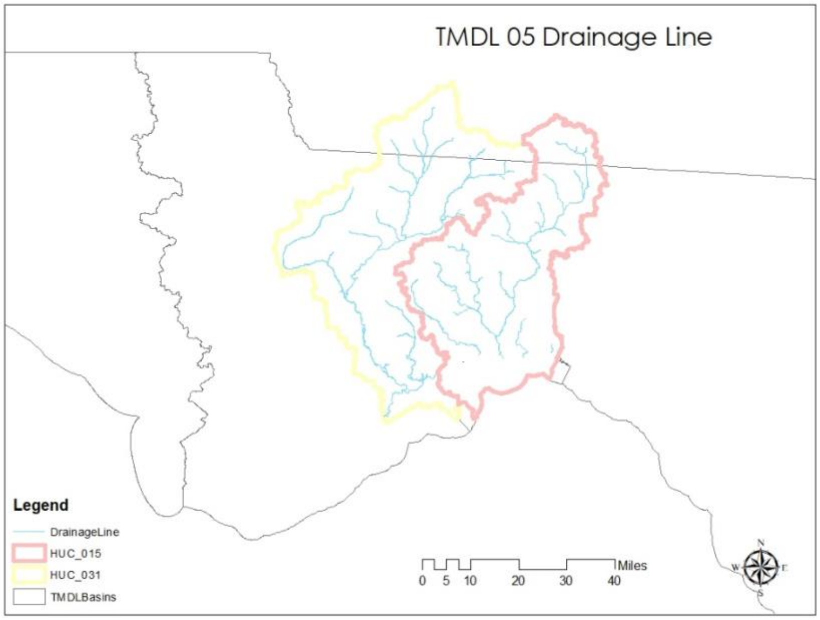

Figure 41. TMDL 05 Flow Paths

The inputs required by the model were prepared based on datasets of DEM, water table, soil storage, and rainfall. The steps are:

1. Area: Basing this information on the DEM values, which were derived from merging the smaller catchments into larger ones, the area was determined and converted to acre-ft.
2. Offsites: These were given to each catchment. Which offsite, was determined by where the water body drained into.
3. The initial stage: This was determined by finding the outlets
4. Ground storage: Data came from soil storage/ ground storage tables
5. Time of concentration: determined by dividing the longest river length by 3600
6. Rainfall: Data was used from precipitation tables
7. Stage-Storage relationship:
8. Structure: Initial stage values were used for gravity structures.

Figures 12-24 are examples interface of the simulation for one catchment in Cascade 2001.

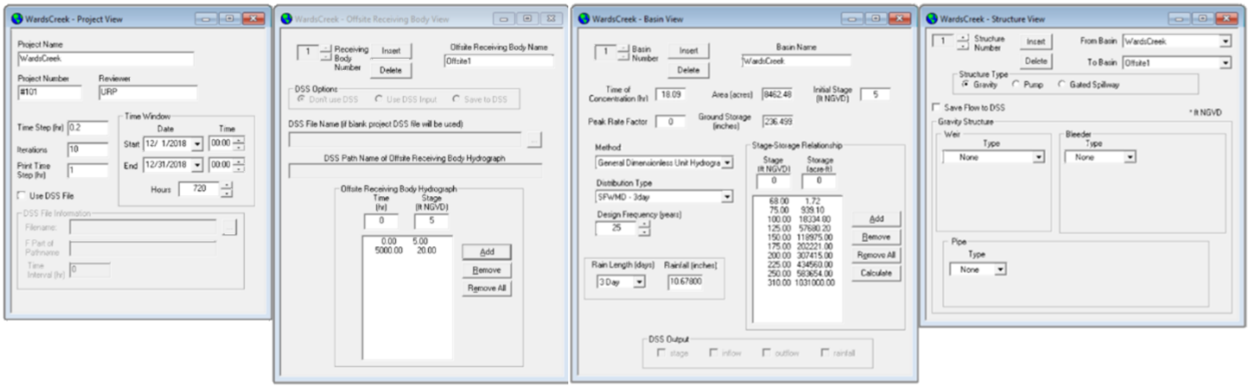

Figure 42. Wards Creek Cascade (HUC_015)

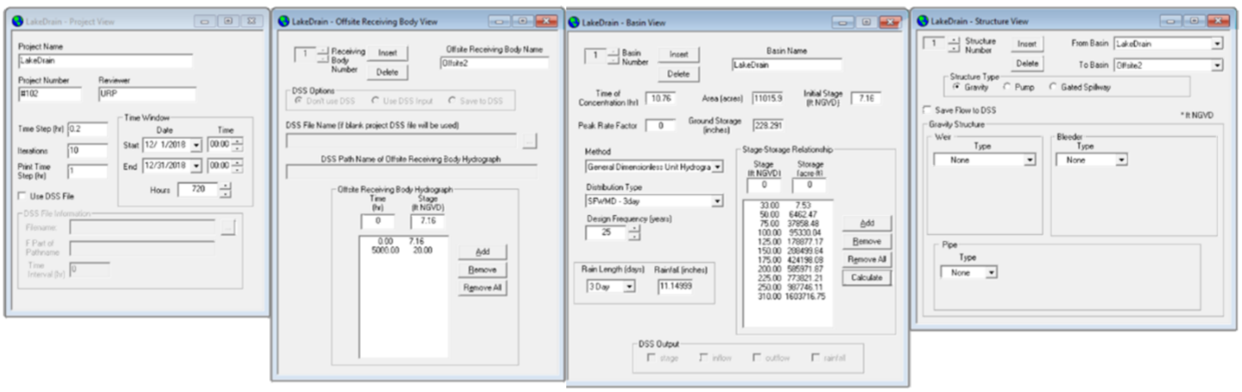

Figure 43. Lake Drain Cascade (HUC_015)

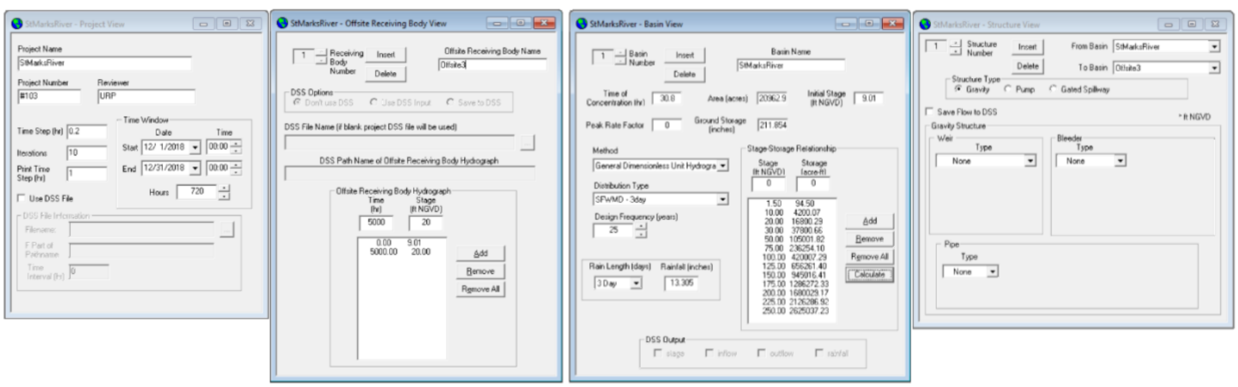

Figure 44. St. Marks River Cascade (HUC_015)

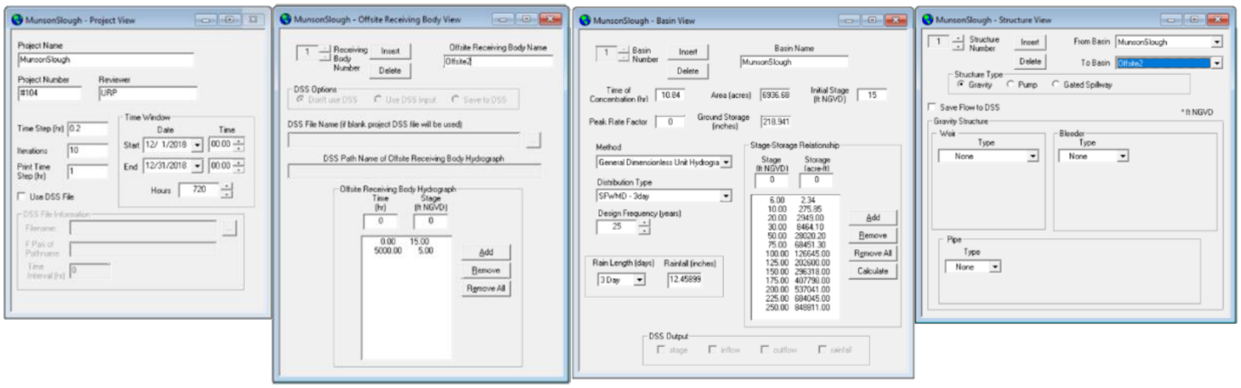

Figure 45. Munson Slough Cascade (HUC_015)

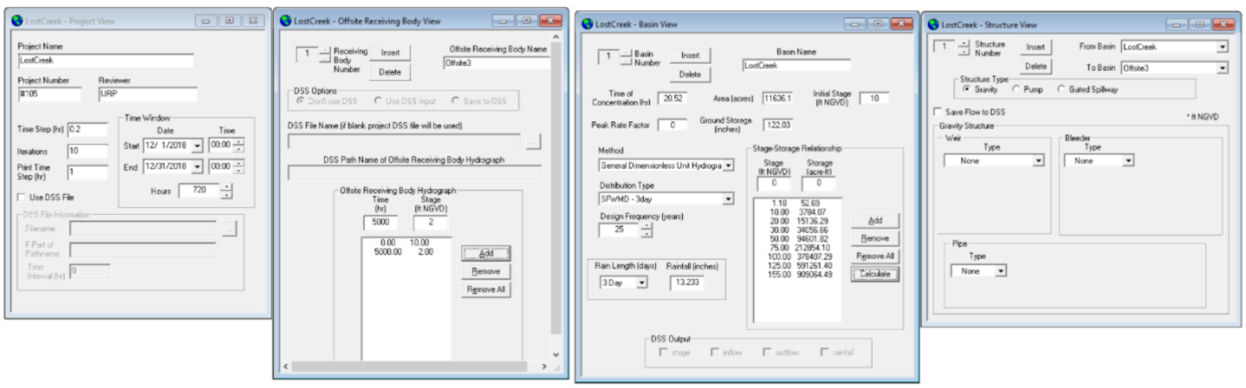

Figure 46. Lost Creek Cascade (HUC_015)

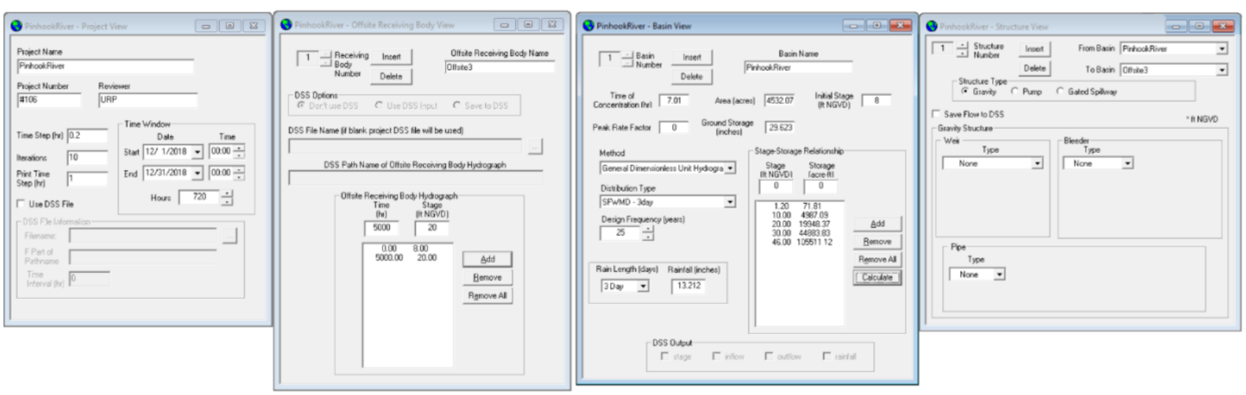

Figure 47. Pinhook River Cascade (HUC_015)

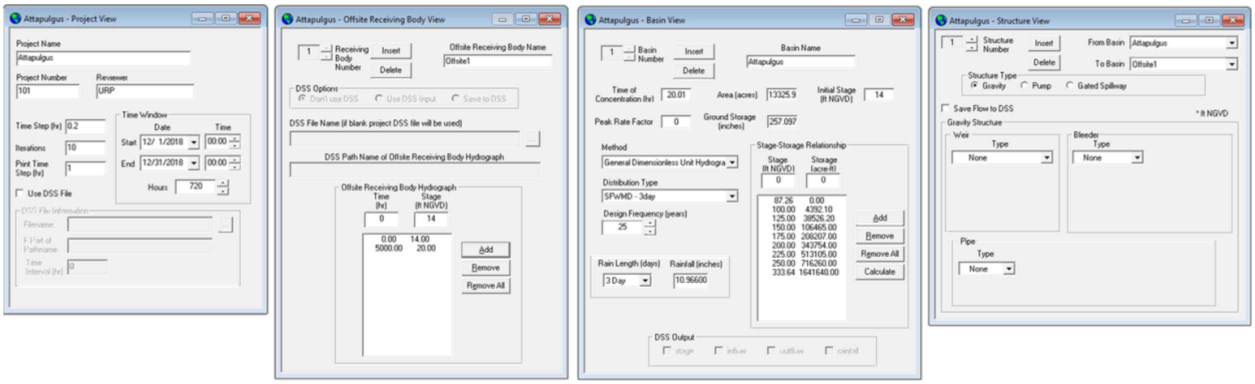

Figure 48. Attapulgus Creek Cascade (HUC_031)

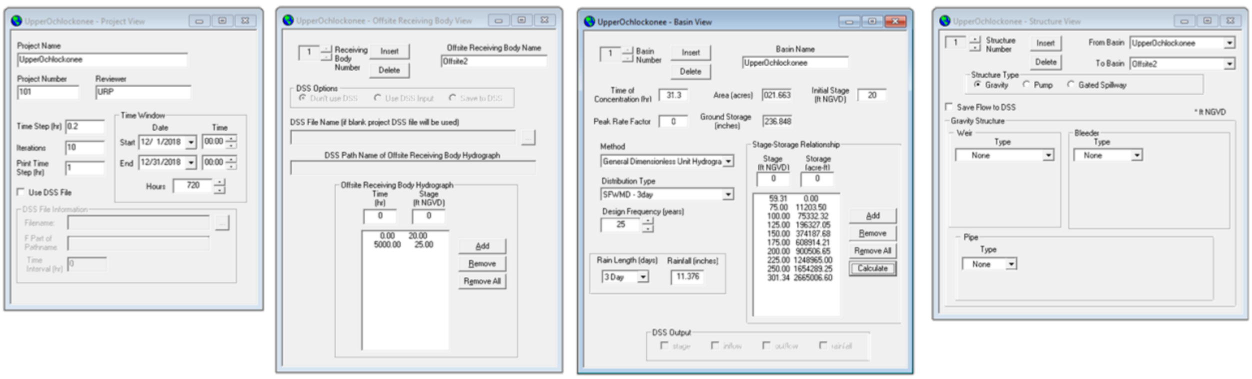

Figure 49. Upper Ochlocknee River Cascade (HUC_031)

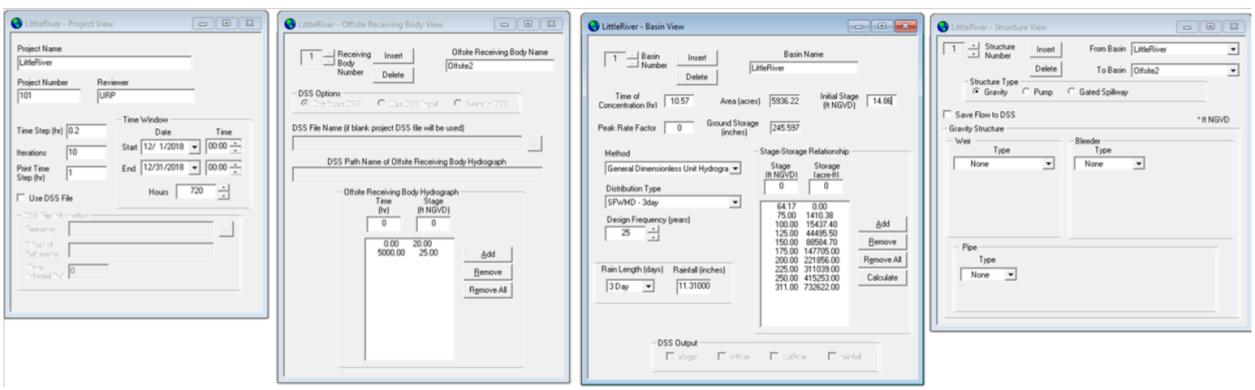

Figure 50. Little River Cascade (HUC_031)

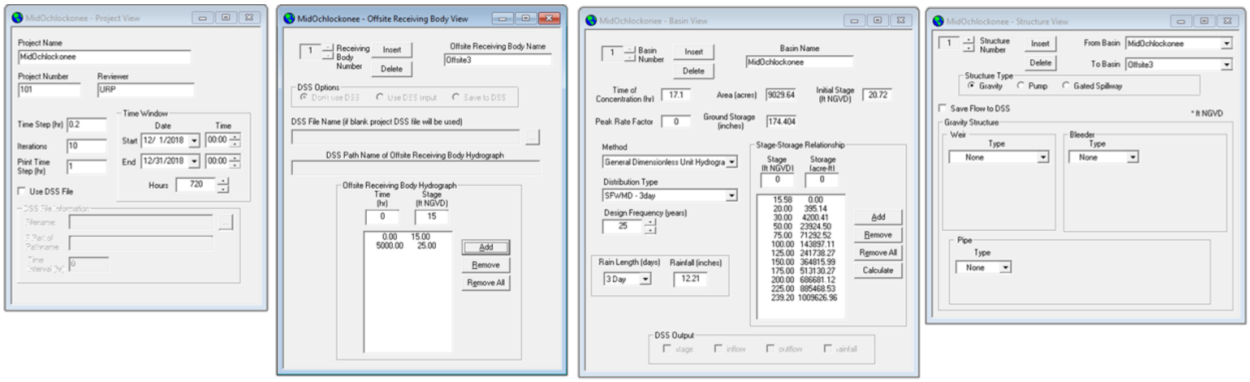

Figure 51. Mid Ochlocknee River Cascade (HUC_031)

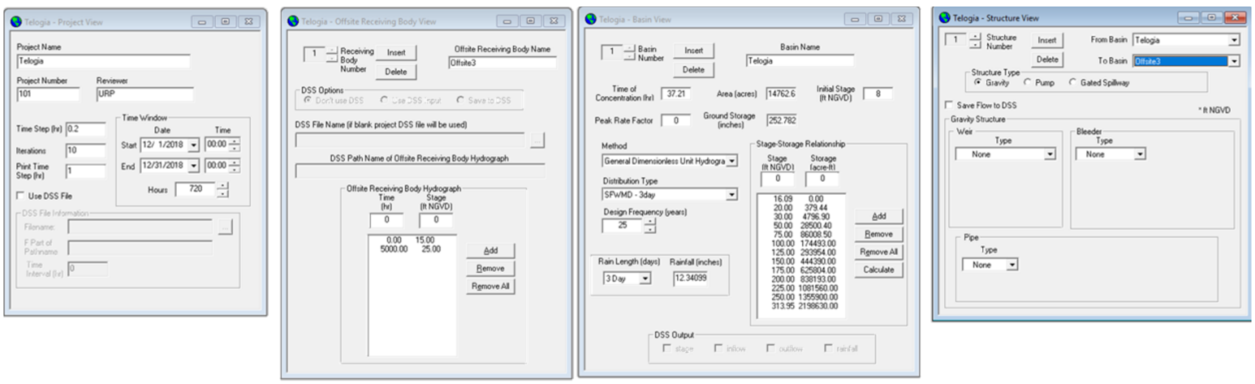

Figure 52. Telogia Creek Cascade (HUC_031)

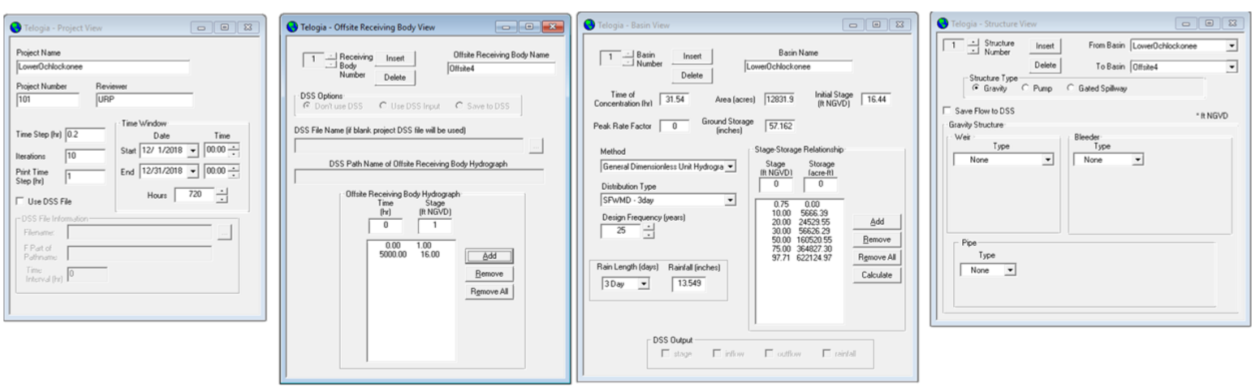

Figure 53. Lower Ochlocknee River Cascade (HUC_031)

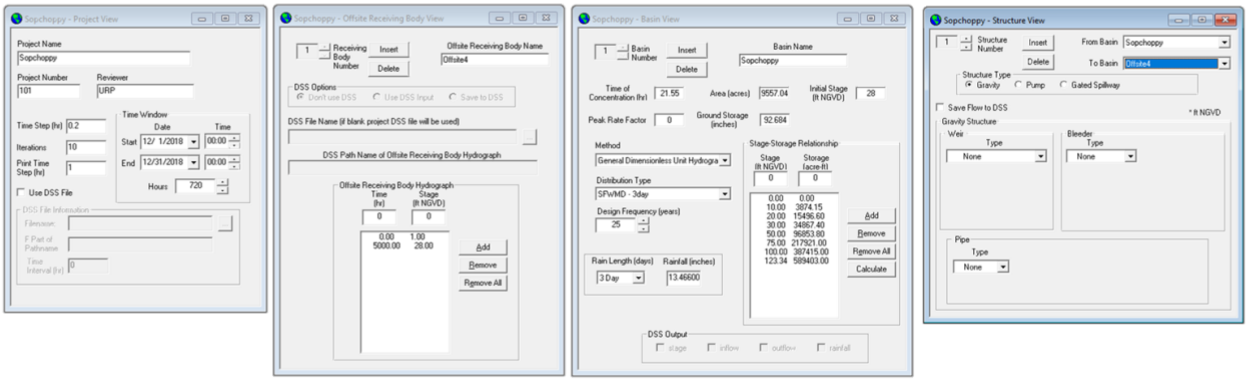

Figure 54. Sopchoppy River Cascade (HUC_031)

3.3. Modeling Results

3.3.1. Vulnerability to Flooding

Based on a 3-day, 25-year, rainfall, the requirements for stormwater permitting in Florida, Figure 25 shows the flood risk risk results for the TMDL Basin 05 which includes Tallahassee, Crawfordsville, Woodville, Quincy, and Havana. The highest flood risk is observed along the coastline and at the confluence of streams, rivers, and the ocean. Flooding is noted along the coast, but also in many inland areas, especially to the far west. The map shows the probability of flooding based on the methodology discussed earlier.

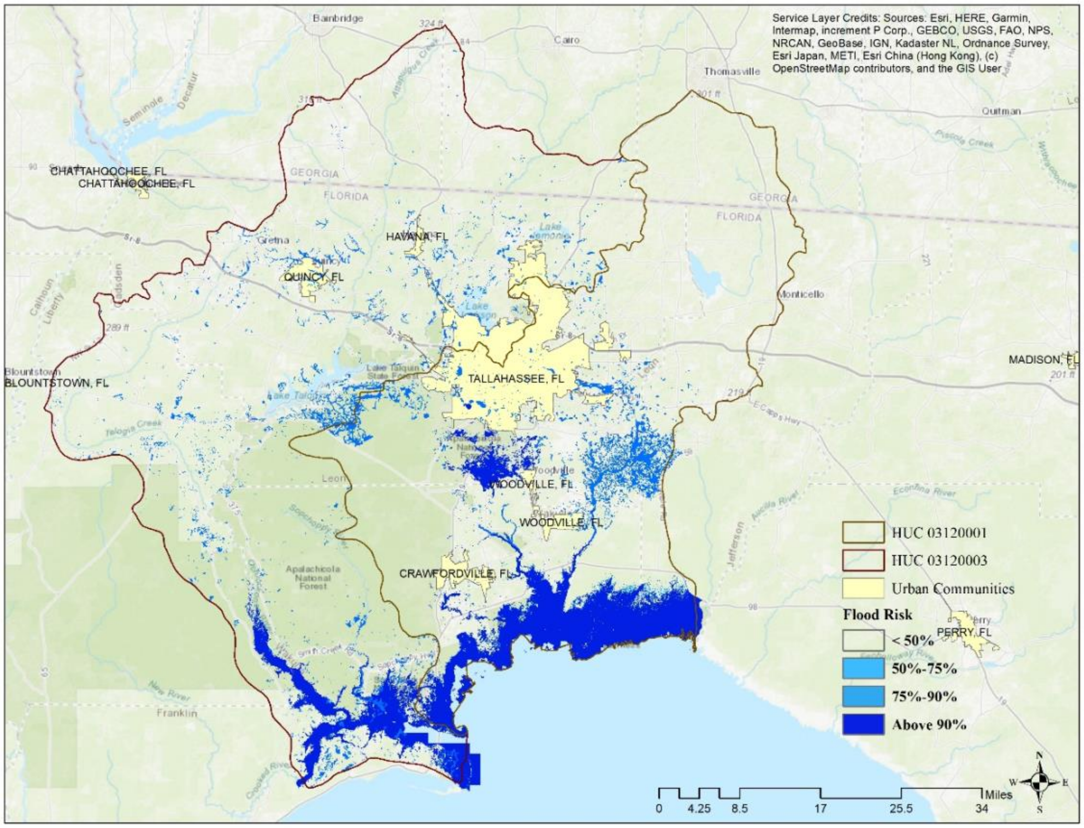

Figure 55. Flood Risk Map

3.3.2. FEMA Flood Map Comparison

For comparison, FEMA flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a "1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. SFHAs are labeled as Zone A, Zone AE, and Zone VE. Figure 26 compares the flood risk zones based on the CASCADE results with the maps provided from FEMA. The two areas do show significant suggesting that the results from CASCADE modeling are valid.

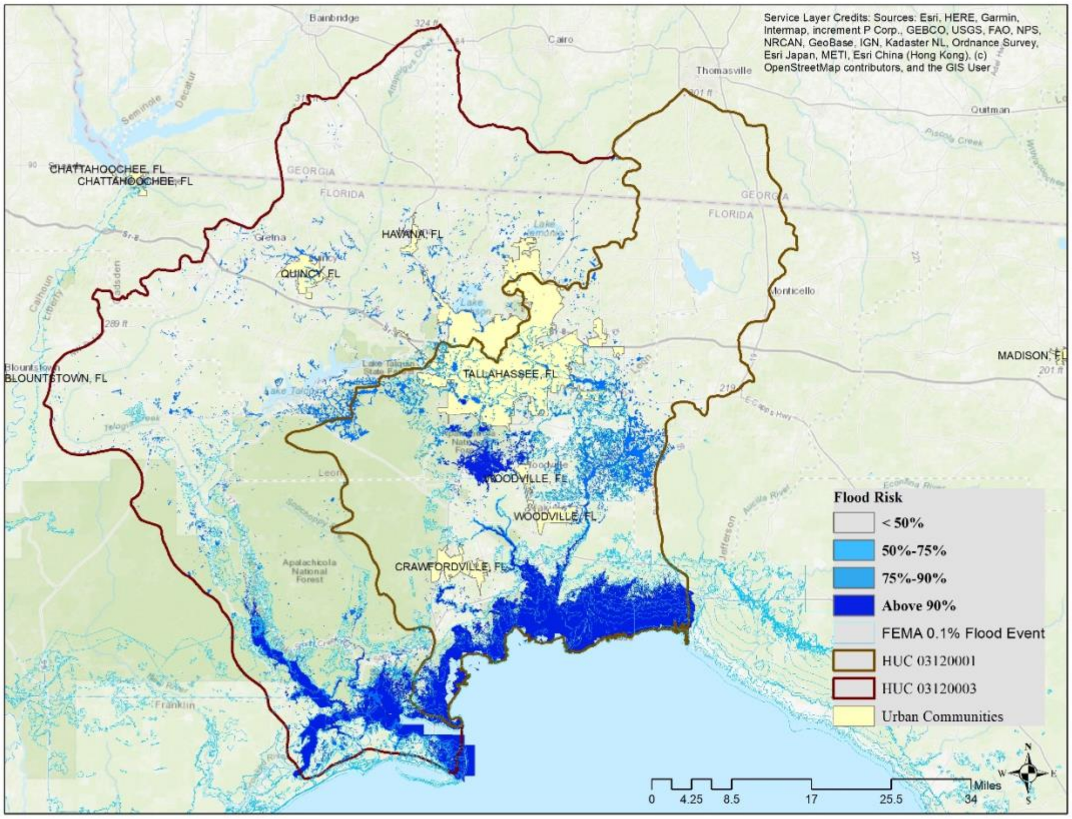

Figure 56. FEMA Flood Map Comparison

Table 4. Comparison between FEMA identified 100-year flood event and the CRT modeled flood region with a high probability for inundation in TMDL Basin #5.

Category	Results
FEMA 1% flooding (total area: km$_2$)	266.3
Modeled flood risk (total area: km$_2$)	194.5
Overlapping area (total area: km$_2$)	166.8
Percent of overlap (FEMA flood zone, in percent)	62.6%
Percent of overlap (estimated flood risk, in percent)	85.6%

3.3.3. Vulnerability to Flooding

The Apalachee Bay – St. Marks TMDL Basin drains includes the Tallahassee Metropolitan Area, which incorporates the City of Tallahassee (with a population of 199,205, as of 2020) and several unincorporated census-designated places, which includes Havana (with a population 1,701), Quincy (with a population 7,171), Woodville (with a population 2,461). The total population of the Tallahassee metropolitan area as of 2018 was 385,145. The area is highly vulnerable to flooding as it drains two rivers (St. Marks River and Ochlocknee). The maps below (Figures 27-30) highlight locations vulnerable to flooding in the western, central and eastern parts of the Tallahassee Metropolitan Area.

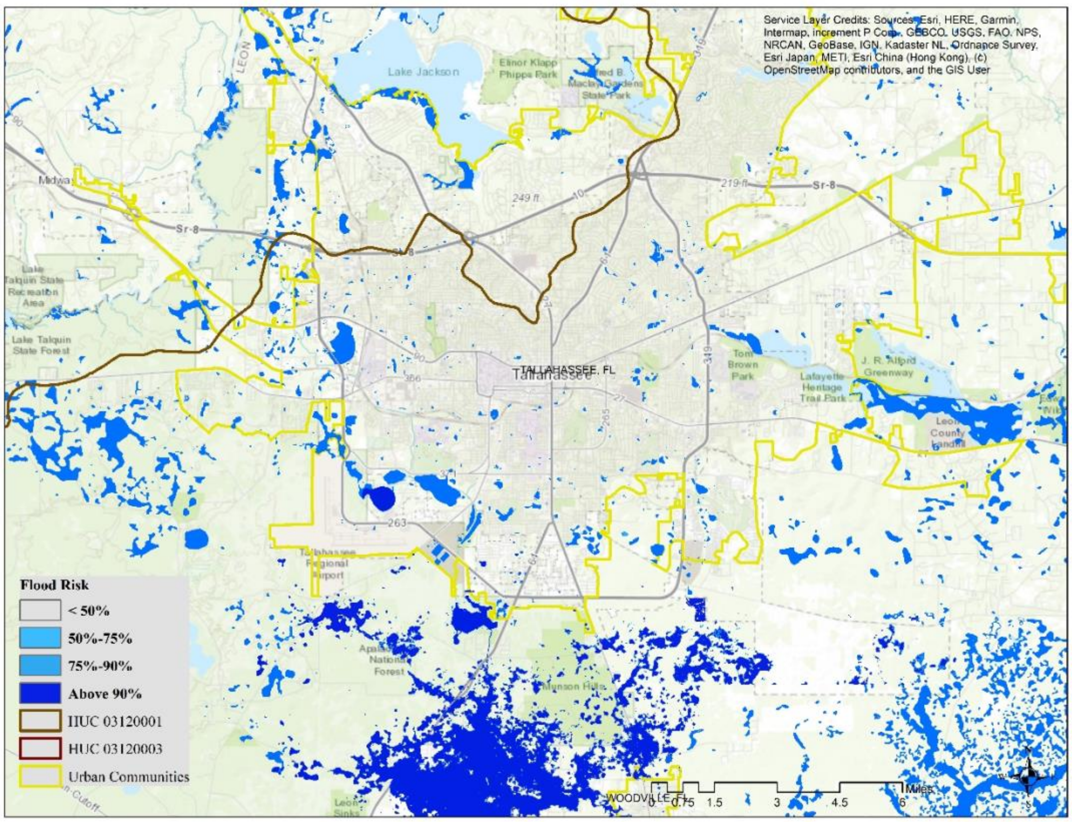

Figure 57. FEMA Flood Map Comparison – City of Tallahassee

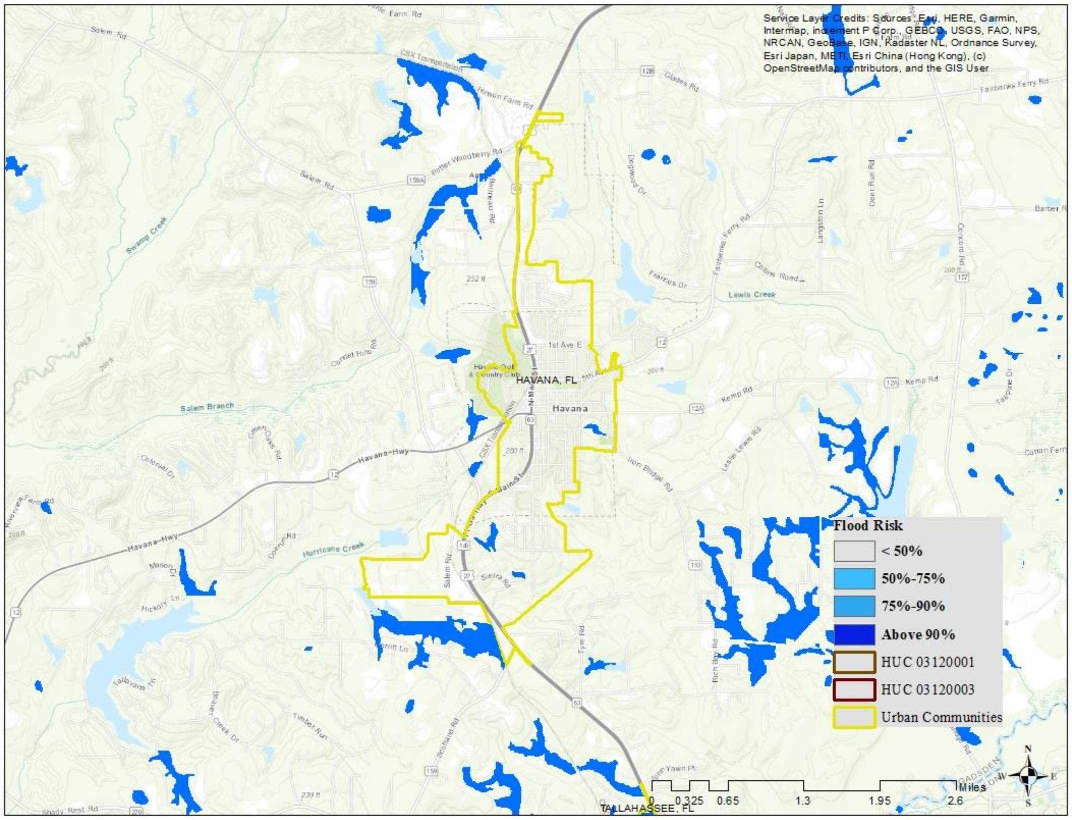

Figure 58. FEMA Flood Map Comparison – City of Havana

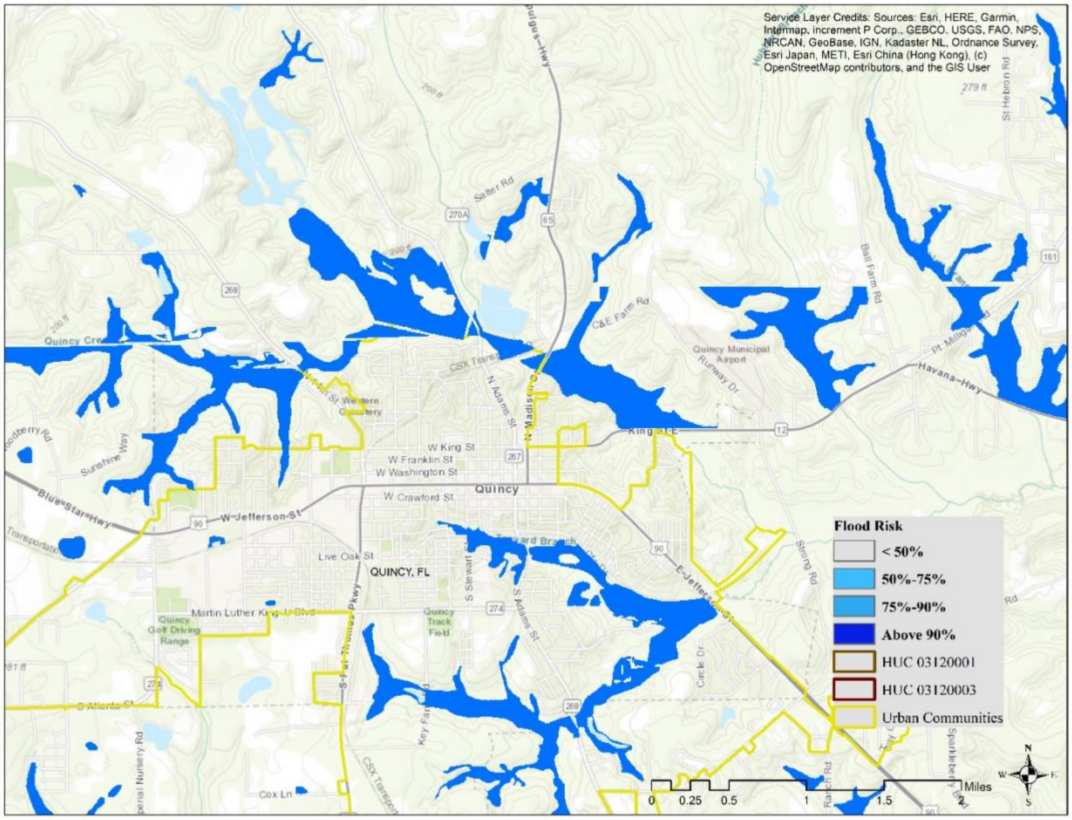

Figure 59. FEMA Flood Map Comparison – City of Quincy

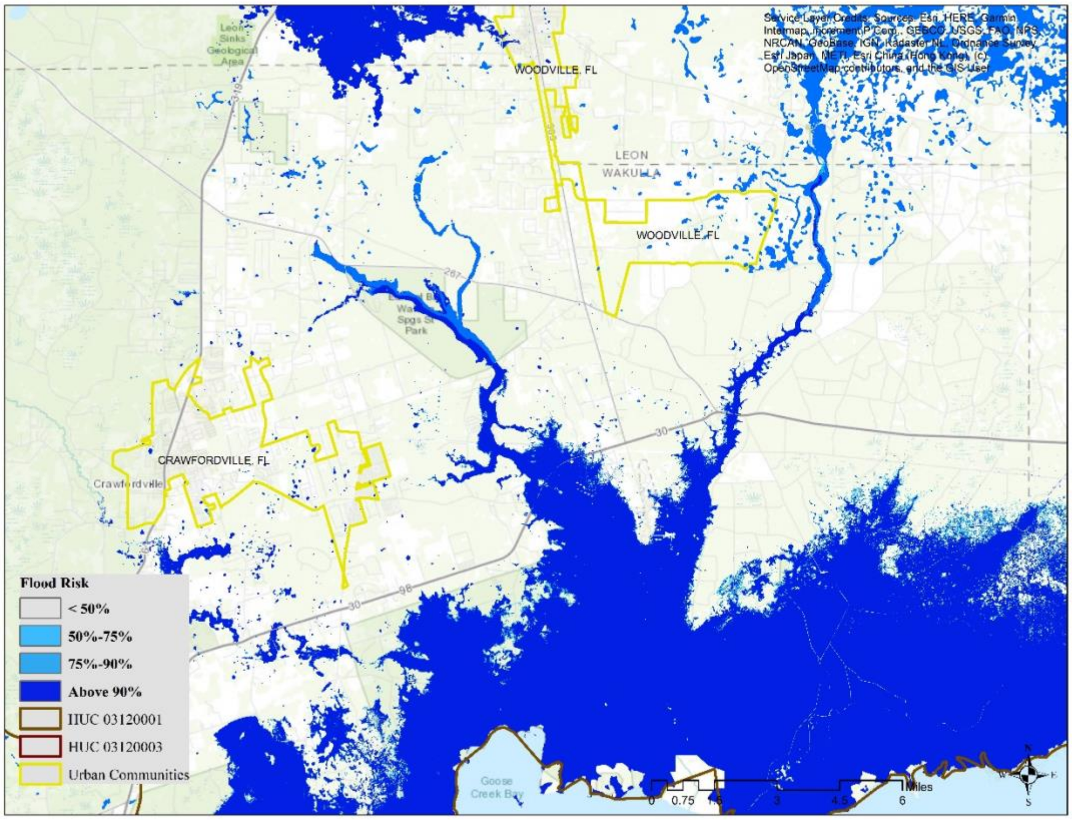

Figure 60. FEMA Flood Map Comparison – City of Woodville

3.3.4. ***Repetitive Loss Comparison***

Figure 31 shows a comparison of the flood map and repetitive loss property locations for the basin. The loss areas coincide with the areas predicted by the FAU model as being at risk for flooding. Most are in the City of Tallahassee or on the beach.

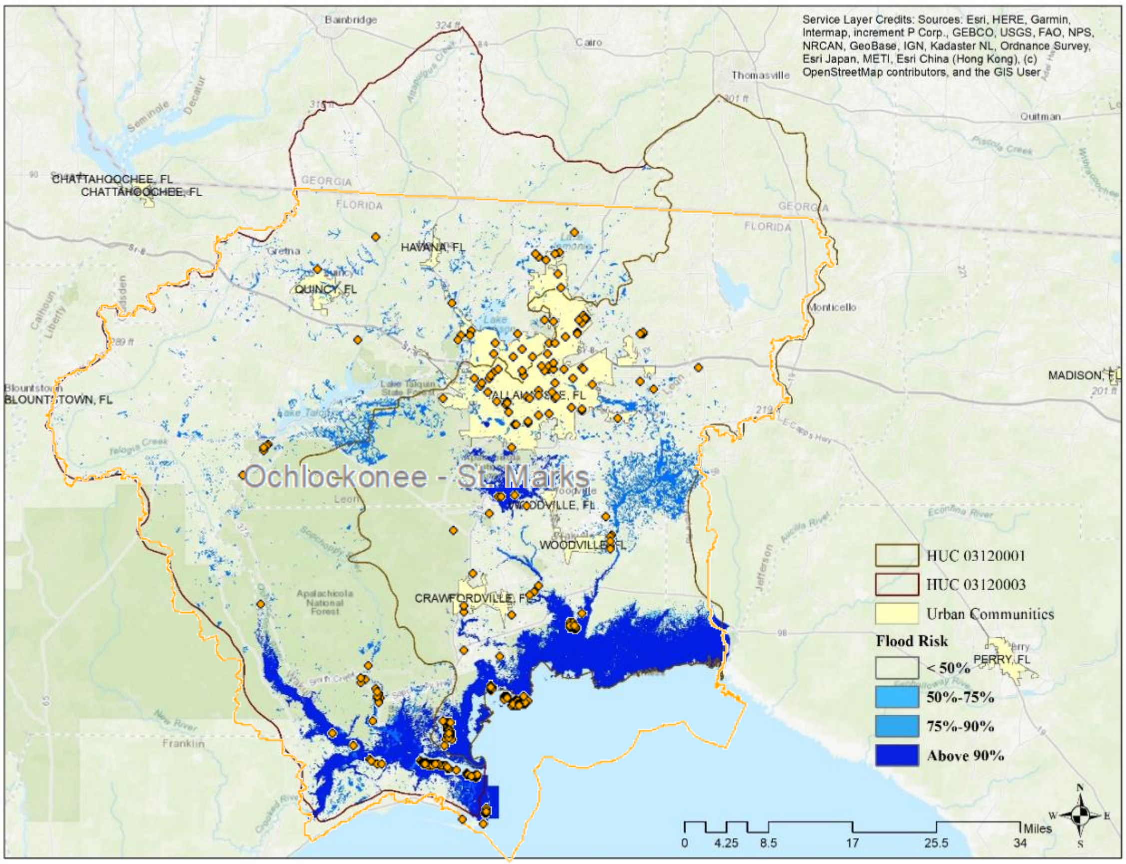

Figure 31. Repetitive loss areas from 2004 -2014 superimposed on the flood risk map created by FAU

4.0 Conclusion

FDEM contracted with FAU to develop a screening tool of flood risk areas for 29 watershed basins. The effort discussed herein focuses on the development procedures for a screening tool to assess risk in the Panhandle area of Florida. The effort discussed herein focusses on the development procedures for a screening tool to assess risk in the Apalachicola watershed basin. The watershed located in Northwest Florida combines readily available data on topography, ground and surface water elevations, tidal data for coastal communities, open space and rainfall to permit an assessment of the risk of inundation of property within the Panhandle Basin.

The basin shows widespread flooding along the beach due to low elevation proximity to the Gulf of Mexico coast and extensive sensitive areas that currently received extensive environmental protection. A drilldown to the local community showed it was are flood prone. The repetitive loss maps confirmed FAU's modeling. Such knowledge permits the development of tools to permit local agencies to develop means to address high risk properties. Solutions to improve flood resiliency in the is basin will yield long term benefits.

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